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Nippon Telegraph and Telephone: Cornerstone of Japan's Electronics Industry

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A Research Paper

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January 1984*

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Nippon Telegraph and Telephone: Cornerstone of Japan's Electronics Industry

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A Research Paper

This paper was prepared by [redacted]
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**Nippon Telegraph and Telephone:
Cornerstone of Japan's
Electronics Industry** ☐

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Key Judgments

*Information available
as of 15 December 1983
was used in this report.*

Nippon Telegraph and Telephone Public Corporation (NTT), the government-owned communications monopoly, has played the leading government role in developing Japan's advanced electronics industries. Through its own R&D efforts and its aggressive support of product development by a select group of private firms, NTT has been an important factor in the emergence of Japan as a world-class competitor in microelectronics, computers, and telecommunications equipment. At the same time, its procurement policies have limited foreign access to the Japanese telecommunications market. These policies have prompted charges of unfair competition and have made NTT, long a low-profile organization, a focus of trade friction. ☐ 25X1

NTT's long-term support of its key supplier companies—NEC, Fujitsu, Oki, and Hitachi—has speeded commercial production of a number of products and facilitated the firms' moves into international markets:

- NTT's research focus has moved beyond telecommunications systems into such areas as semiconductors and computers, deemed essential to providing advanced communications services. By assuming the bulk of early development and engineering costs for many of the items it requires, NTT has reduced the firms' R&D costs for developing new product and process technologies.
- As a consumer of advanced electronic products, NTT has helped underwrite commercial development costs as well as assisted in product definition—enhancing corporate planning and production at scale economies. Although its share of the Japanese market has declined in recent years, NTT remains a large and virtually guaranteed source of demand.
- At the same time, NTT limits foreign sales to the Japanese telecommunications market through its procurement approval process, its extensive use of privately negotiated contracts, and its limited release of critical technical specifications.
- NTT support has not only helped Japanese firms to price their products competitively but has also played a role in promoting Japanese telecommunications equipment exports, particularly to developing countries.

The electronics industry benefits more from NTT support than it does from R&D subsidies provided by MITI. ☐ 25X1

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Because of the integral role NTT has played in the emergence of the Japanese electronics industry, NTT and industry officials view the US-Japanese procurement negotiations as more than just a market access issue. Changes in NTT procurement, for them, imply tampering with a system that has, in large part, been responsible for the rapid rise of Japanese electronics. Consequently their resistance to liberalized procurement stems from fears of a loss of overall capabilities, as well as reluctance to give up a share of the home market. We believe NTT will use its planned Information Network System program to continue support to domestic electronics firms and to limit foreign firms' participation in the Japanese market.

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The proposed reorganization of NTT toward private ownership—an issue now being debated in Japan—holds major implications both for Japan's ability to compete in the fast-moving international telecommunications market and for foreign access to selected Japanese high-technology markets. We believe that a reorganization is likely, but it is far too early to determine its final form and impact. At a minimum, a broadening of the base of supplier firms is likely. Whether a diffusion of NTT relationships with private firms will help or hinder Japanese competitiveness remains to be seen.

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Reorganization and deregulation, however, are likely to increase competition in areas where NTT has traditionally been a monopoly provider of services. NTT has been positioning itself to compete in the rapidly growing advanced telecommunications services market as well as to control the telecommunications equipment markets. NTT will benefit from the proposed Ministry of Posts and Telecommunications bill to limit foreign access to the Japanese telecommunications services market. Moreover, privatization could reduce Tokyo's leverage on NTT to honor future bilateral agreements on procurement. It is also unlikely to open Japanese markets to foreign suppliers because of longstanding supplier relationships with NTT.

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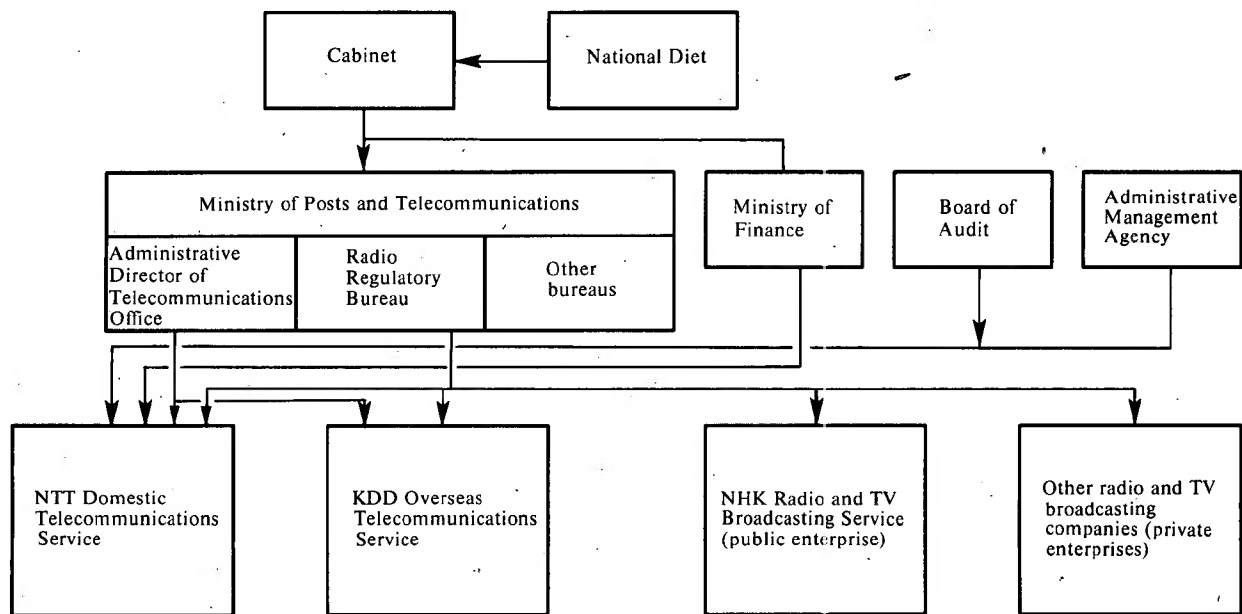
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Figure 1
Japan: Government Regulation of the Telecommunications Industry



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Nippon Telegraph and Telephone: Cornerstone of Japan's Electronics Industry ☐

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The Corporation

Created in 1952 during the Allied occupation, the Nippon Telegraph and Telephone Public Corporation (NTT) is Japan's government-owned but nominally independent telecommunications monopoly. Since its inception, NTT has grown into one of the largest corporations in Japan and will be the world's second-largest telephone company after the breakup of American Telephone and Telegraph (AT&T). NTT provides a range of services of the standard variety offered by other public telephone and telegraph companies including telephone, telegraph, telex, data communications and leased lines, and also a number of more advanced services, such as facsimile communications.¹ NTT is the nation's second-largest government employer, after the Japan National Railways.

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Despite being subject to government supervision, NTT's public corporation status has given it more independence than most government agencies (figure 1). Its president and top management are appointed by the Cabinet, with consent of the Diet. Its rates are set by the Ministry of Posts and Telecommunications and approved by the Diet. Although NTT is a self-financed corporation, its annual budget must also be approved by the Diet, after review by the Ministry of Finance. Japanese law has set only basic guidelines for NTT operations, leaving specific business decisions to the monopoly. ☐

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The NTT bureaucracy is large and, by the public admission of some officers, unwieldy. The corporation is divided into several divisions and hundreds of subordinate offices (figure 2). Despite a clear-cut chain of command on paper, most major decisions are achieved after considerable interoffice politicking and consensus formation. ☐ In

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¹ A process by which fixed graphic material including pictures or images is scanned and the information converted into electrical signal waves, which are used either locally or remotely to produce in record form a likeness (facsimile) of the subject copy. ☐

the process, major proposals for action often must pass through at least 11 layers of management before a final decision is taken. Although President Hisashi Shinto was appointed in January 1981 to streamline the corporation, implement the US-Japan Bilateral Agreement, and make its markets more accessible to foreign manufacturers, he is ☐ facing considerable resistance.² ☐

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Promoting the Electronics Industry

NTT has used its size and monopoly power to influence the development of the electronics industry upon which it relies. Prohibited by law from manufacturing, NTT instead has exploited its substantial R&D resources and its leverage as a major purchaser of electronic equipment to guide and enhance technological development in key electronics sectors, shelter the Japanese telecommunications market from foreign competition, and increase the price competitiveness of specific Japanese firms in foreign markets. Although firms have decreased their dependence on sales to NTT, its \$3 billion annual procurement reduces the risks of new product development, in part by guaranteeing an initial sales base. Moreover, NTT is able to influence additional corporate sales within the Japanese telecommunications market through its control of equipment standards and specifications. This support often provides Japanese firms with a strong basis for competing in international communications markets. ☐

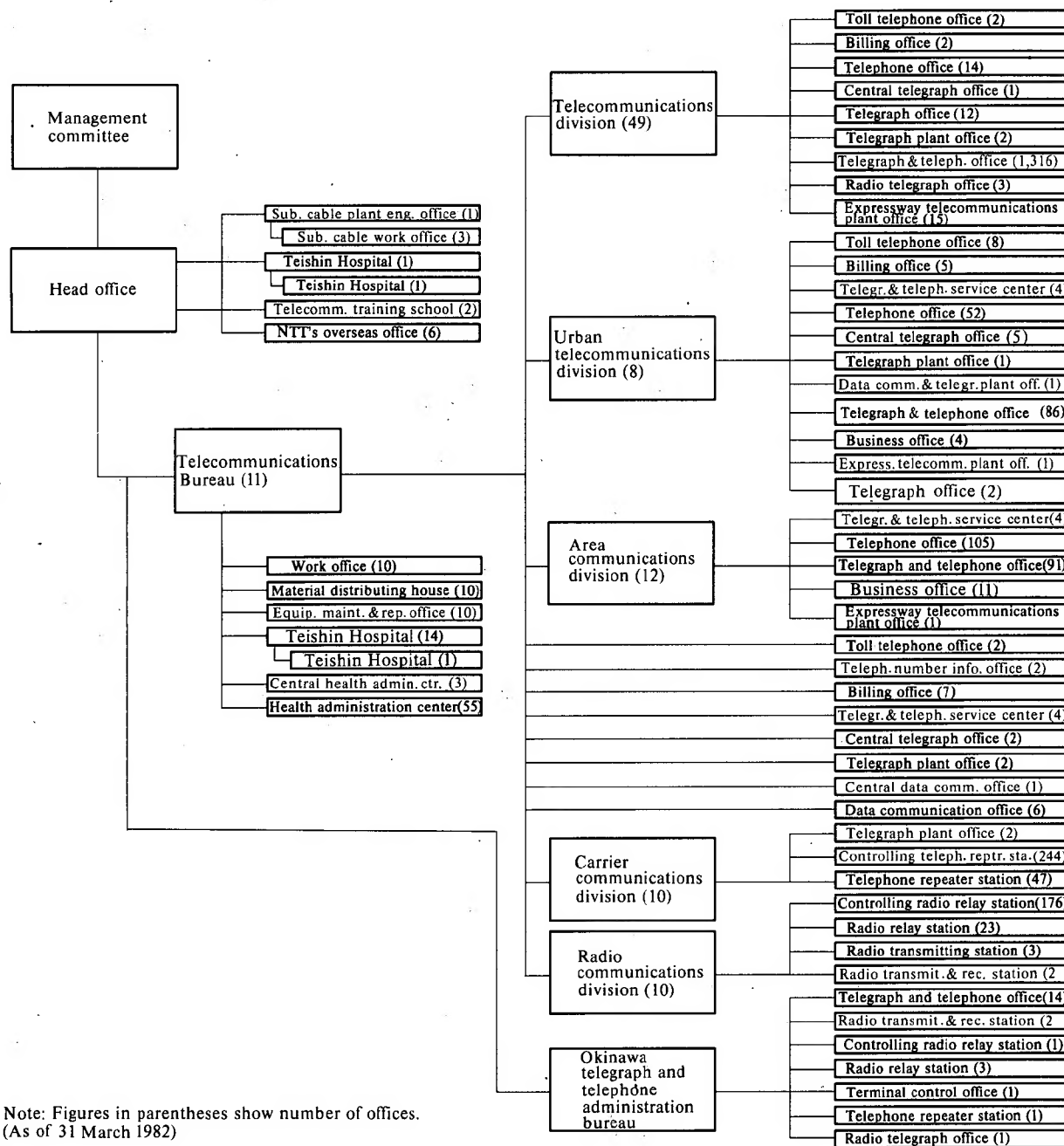
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NTT has several motives for taking an active role in electronics development. NTT officials have stated privately that they want to avoid dependence on private firms for development of key telecommunications equipment, a concern that has grown as operating costs and the pace of the electronics revolution

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Figure 2
NTT: Corporate Organization



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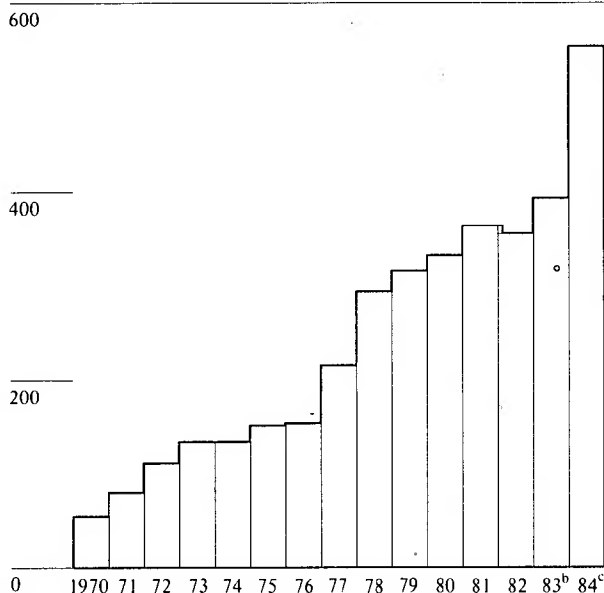
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Figure 3
NTT: Research and Development
Spending, by Year^a

Research and Development Spending

Million \$



Percent of Revenues

4.0

3.0

2.0

1.0 1970 71 72 73 74 75 76 77 78 79 80 81 82 83^b84^c

^a Fiscal years.

^b NTT plan.

^c 1984 budgeted.

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have both accelerated in recent years and that may intensify with privatization. Because of NTT's government ownership, the leadership of the corporation has also viewed support of Japanese industrial development as a major responsibility, [redacted]

[redacted] Moreover, through "amakudari," the process by which NTT officials retire to high-paying jobs in private companies, a close-knit relationship has evolved over the decades between NTT and its principal suppliers. [redacted]

R&D Support

We believe NTT's long-term and stable support of R&D is its major contribution to the rapid development of advanced electronics in Japan. [redacted]

NTT's R&D activities are currently focused on the following areas (figure 4):

- Advanced switching communications networks consume almost 30 percent of the R&D budget. The work is critical to the proposed integrated telecommunications network system, the Information Network System.
- Advanced microelectronics accounts for 12 percent of R&D spending. Major research efforts include integrated circuitry for a wide range of telecommunications-related equipment including new types of devices based on gallium arsenide and Josephson-junctions superconducting technologies.
- Computers have taken roughly 20 percent of the R&D budget. NTT is currently participating in Japan's Fifth-Generation Computer Project, including development of artificial intelligence, speech recognition, and language translation.

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- Fiber optics accounts for only 6 percent of R&D spending, but NTT is a world leader in this technology.

- Communications satellites now consume 9 percent of the budget, up from 3 percent in 1978. []

NTT has been able to save time and money by concentrating its R&D effort on applied rather than pure research. []

Moreover, it has established a system to collect, translate, and publish foreign research results.

[] significant state-of-the-art knowledge (such as high electron mobility transistors) has been gained through this practice. By focusing its R&D resources on key technology areas and providing the results to major Japanese firms, NTT has fostered a rapid pace of advanced product development. []

The Joint R&D Process. Through joint R&D,³ NTT provides firms with technical know-how. Embassy reporting indicates that NTT generally determines the basic direction of research for products that it plans to purchase, with its Engineering and Procurement Bureaus often the most important links in the decisionmaking process. The following steps are then taken:

- Basic product and process technologies are developed in house through extensive applied research. From this work come test data, basic manufacturing know-how, new materials, and patents—all proprietary information of NTT—which are transferred to the firms.
- Prototypes are developed and tested by NTT engineers—most often with private electronics firms—to determine technical feasibility.

³ Not all NTT-sponsored R&D is done jointly with supplier firms; some R&D is contracted totally to the firms. In other cases, NTT accepts products developed by the firms without NTT sponsorship. []

The NTT Laboratories

NTT's four electrical communications laboratories (ECLs) represent the core of its support to Japanese advanced electronics. The laboratories conduct virtually all NTT applied R&D and account for about 95 percent of NTT's R&D budget. The ECLs provide basic technical data required for improving existing NTT operations and for purchasing new equipment. After receiving NTT research requirements from the Engineering Bureau, the ECLs perform R&D to produce technical documentation for technical standards and procurement specifications. []

Although the work of the four laboratories overlaps, each ECL concentrates on substantially different areas of research:

- *Musashino is the oldest, largest, and presumably the highest budgeted ECL. Work at this laboratory is focused on digital switching and software development for the Fifth-Generation Computer.*
 - *Yokosuka is the second-largest NTT laboratory, with primary responsibility for developing transmission technology for the integrated communications network system to link computers and telecommunications equipment. It is also working on satellite communications.*
 - *Atsugi, established in 1983, conducts the bulk of NTT semiconductor-related exploratory research, from materials production to the design, manufacture, and testing of components. As a result, it is the center of NTT's participation in semiconductor and VLSI development.*
 - *Ibaraki, although the smallest of the four laboratories, is the largest Japanese R&D facility working on fiber optics production technology. This laboratory is also responsible for development of some advanced materials for microelectronics components.* []
-

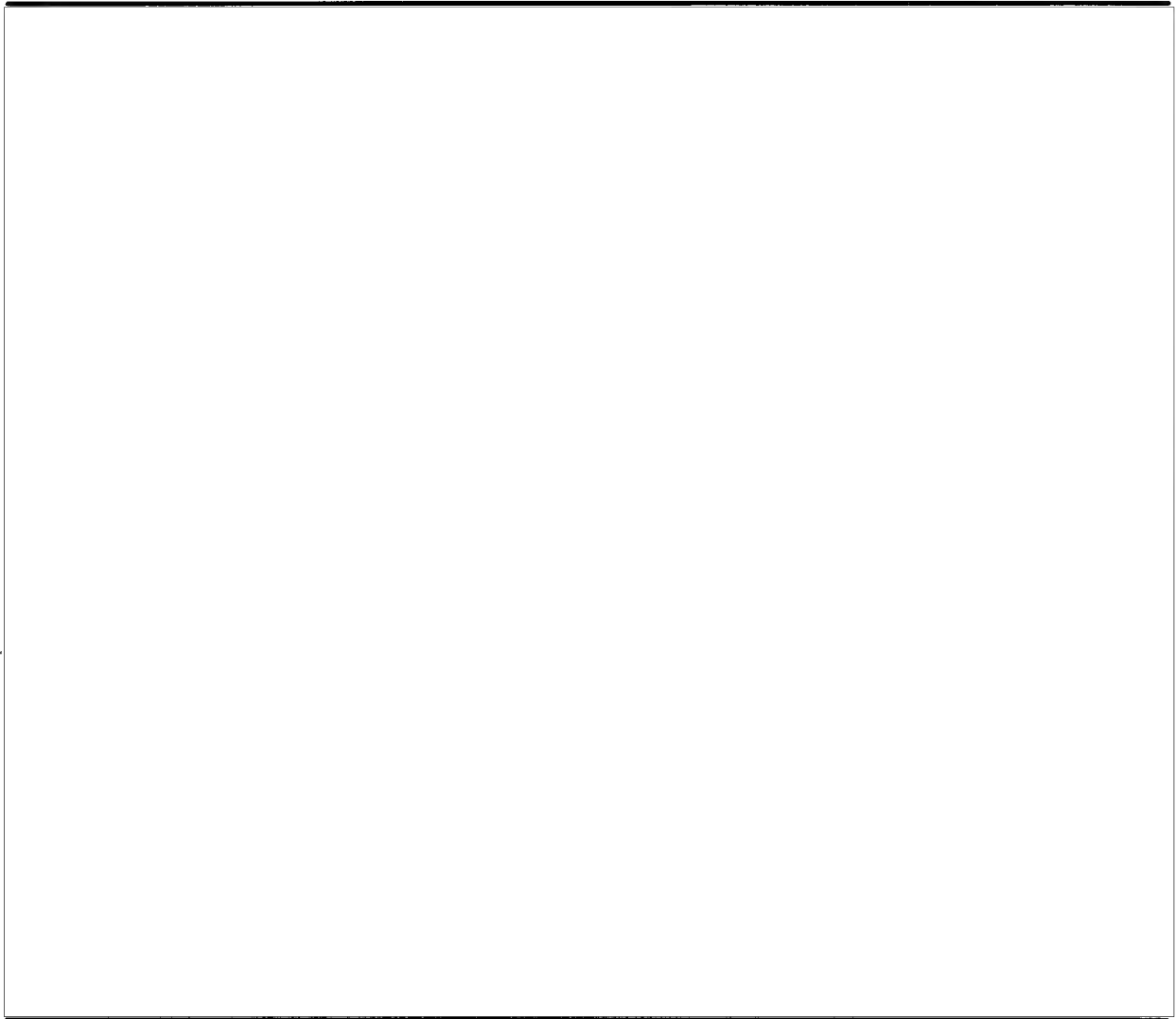
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- The same firms are usually selected to develop commercial product designs and manufacturing processes based on specifications drawn up by the NTT Engineering Bureau. Several prototypes are produced, and NTT chooses models for mass production.
- NTT then decides which firms will produce the product and allows them to use its patents.

this R&D process also reduces the costs and risks of NTT product development for participating firms. Embassy interviews with NTT officials indicate that NTT finances most of the research up through the production engineering phase. We believe this funding includes NTT's limited pure research and acquisition of

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research data from abroad, its applied research and prototype development, and much of the product design work performed by participating firms. Because NTT pays for much of the R&D effort, including the expensive phases of development and product engineering, Japanese electronics firms are able to build upon NTT R&D and focus their own resources on commercial products. []

Technology Transfer. NTT has fostered a sizable transfer of technology to the private sector. Besides traditional telecommunications activities, NTT has worked closely with its major suppliers in such areas as very-large-scale integrated circuits (VLSI), main-frame computers, and optical fibers. The companies have obtained substantial process know-how from exchanging data and research personnel, building prototypes to NTT specifications, and acquiring joint patents. [] NTT also provides guidance through regular meetings with family firms (see inset) and through its participation in electronics industry associations. Such formal and informal contacts reportedly promote increased cooperation where NTT and private firms are pursuing parallel R&D. For example, []

NTT has also been able to increase the capabilities of less advanced electronics firms by selling them technology through the Nippon Telecommunication Engineering Company (NTEC), a major channel for the subsidized sale of NTT patents. Established in 1976 as a private consulting firm, NTEC is 30 percent owned by NTT; other major stockholders include the Nippon Electric Company (NEC), Fujitsu, Oki, Hitachi, and several banks. Approximately 350 small and medium-size Japanese companies regularly receive an NTEC journal listing available NTT technology. Since its creation, the organization has sold more than 800 licenses.⁴ []

By providing technical support to private industry, NTT has been able to influence the direction and quality of research in Japanese advanced electronics. Moreover, its own research effort and its procurement decisions provide a guidepost for private research and development. NTT also influences corporate research through formal and informal disclosure of its interest in specific products. []

[] the major electronics firms often direct R&D toward products for which NTT has indicated it will allocate future procurement funds. []

Procurement Policies

NTT's other vital means of supporting Japan's advanced electronics industry is its purchase of telecommunications equipment and related electronics products. In accounting for a large portion of the Japanese market, NTT has provided a steady source of demand for both major and many smaller equipment suppliers (table 1). More importantly, NTT procurement has been a key factor in assuring Japanese electronics firms a flow of funds, a guaranteed market, and an outlet for new technologies. Although its share of purchases of Japanese telecommunications products has dropped over the past decade (because private demand has risen rapidly), NTT:

- Is the single largest purchaser of telecommunications equipment in Japan.
- Accounts for more than 80 percent of the total \$2 billion Japanese Government purchases of telecommunications equipment from Japanese firms.
- Is the dominant consumer in many product areas such as switching equipment. []

[] Japanese electronics companies recover much of their own R&D expenses through guaranteed product sales to NTT. []

[] NTT decides the size of the order each manufacturer will get in accordance with the share each manufacturer has contributed to joint research. This implies that research costs are recouped in the price of equipment sold to NTT. Guaranteed purchases by NTT also enable Japanese firms to establish small-scale production operations that allow them to gain valuable early production

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The NTT Family

During the past 30 years, NTT has developed a close relationship with about 200 Japanese companies that supply most of its equipment needs. These companies include well-known giants of the Japanese electronics industry as well as firms that supply cable and construction services. Communications between NTT and its supplier family can occur in a variety of ways—ranging from joint R&D projects to direct liaison—and are usually facilitated by executive personnel affiliation. For example, []

[] the top 10 construction contractors for NTT received 60 percent of their executives from NTT. In addition, [] NTT provides guidance to firms through the Communications Industry Association of Japan (CIAJ). The CIAJ—whose director is a former NTT executive—comprises 176 electronics firms that account for 90 percent of Japan's telecommunications production. []

NTT procurement, however, is dominated by a handful of companies. In 1982 the 10 leading suppliers met roughly 60 percent of NTT's \$3 billion in procurement, while the four largest satisfied about 40 percent. These "Big Four" firms^a are:

- **Nippon Electric Company.** Japan's largest producer of telecommunications equipment and semiconductors, NEC, is also NTT's largest supplier. Sales to NTT accounted for nearly \$500 million, or 10 percent, of NEC's total revenues. NEC's greatest strengths are in telephone switching—especially digital systems—in earth stations and microwave systems.

- **Fujitsu.** The leading Japanese computer manufacturer ranks second to NEC in telecommunications sales. In 1982 total telecommunications sales were about \$560 million, with NTT accounting for over \$300 million. In Japan, Fujitsu ranks second to NEC in microwave equipment, carrier transmission, central office gear, and fiber optics. The executive director for engineering and the senior auditors are NTT retirees.

- **Oki Electric.** Although the smallest of the "Big Four" suppliers (\$1 billion in sales), Oki has probably benefited most from NTT support. The firm relies on NTT not only for 40 percent of its sales but also for extensive technical support. For example, although Oki did not participate in the NTT VLSI effort, Japanese press articles indicate that NTT supplied Oki the 64K RAM technology. []

[] Oki has also received NTT support for its 256K RAM development. The close ties between Oki and NTT are facilitated by the large number of retired NTT officials who work at Oki, including three of Oki's five directors.

- **Hitachi.** Hitachi is one of the world's largest, most diversified manufacturers. It produces nearly 20,000 different products, including computers and telecommunications equipment. Hitachi is one of NTT's major suppliers of switching systems and sold it about \$160 million in telecommunications equipment in 1982. []

^a The firms also control more than 10 middle-ranking producers through capital participation or sustained contracting. []

experience. Early NTT orders for 256K DRAMs, for example, will allow Japanese semiconductor firms to acquire initial test and operating data in hopes of establishing volume production and a de facto industry standard. Industry executives indicate that by providing a guaranteed market for new technologies and underwriting development risks, Japanese firms are able to invest in plant and equipment earlier than

they might have otherwise. Moreover, this support enables Japanese firms to price their commercial products very competitively because they do not have to recover a substantial proportion of expensive R&D costs. []

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Table 1 Percent
Japan: Telecommunications Equipment Orders

| | 1970 | 1975 | 1977 | 1980 | 1981 |
|------------------|------------|------------|------------|------------|------------|
| Total | 100 | 100 | 100 | 100 | 100 |
| NTT | 52 | 49 | 44 | 38 | 33 |
| Other government | 9 | 8 | 8 | 9 | 8 |
| Private/domestic | 27 | 22 | 24 | 31 | 33 |
| Foreign | 12 | 21 | 24 | 22 | 26 |

Source: Communication Industry Association of Japan.

Evidence also indicates that NTT purchases are a source of substantial subsidies to the electronics industry. According to Embassy reporting, tentative prices are set by NTT when it contracts for initial production of new equipment, but final prices are not established until after NTT surveys production costs at the producing plant.

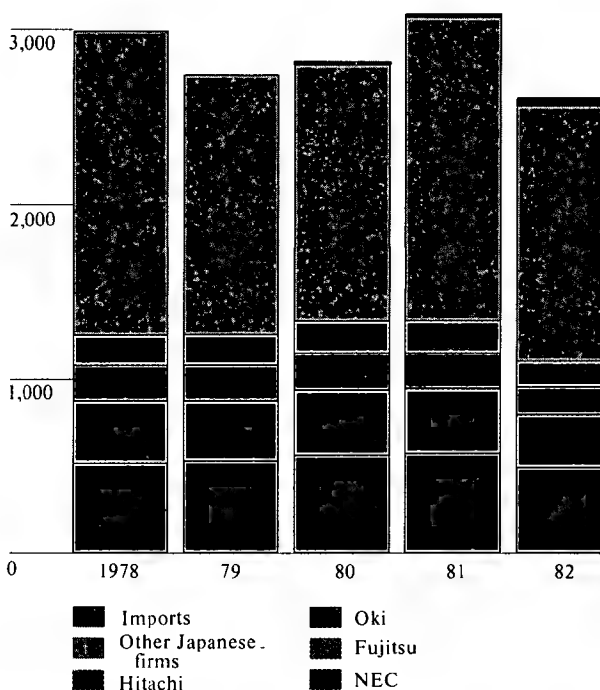
Favoring Domestic Suppliers. NTT procurement has long favored Japanese companies; domestic firms still account for more than 97 percent of NTT purchases (figure 5).

the close relationship between NTT and its family of domestic suppliers has been resistant to major modification. Key NTT leaders—particularly in the powerful Engineering Bureau—reportedly have been reluctant to alter their support of big

Figure 5
NTT: Total Procurement, by Year

Million US \$

4,000



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suppliers despite NTT President Shinto's publicized efforts to open the procurement process.

middle-level engineers, who heavily influence major procurement decisions, have been far less concerned with international pressures to expand foreign purchases than are more senior officials and can slow down the review and approval of foreign firms' applications.

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NTT's Procurement System

As a result of the US-Japan Bilateral Trade Agreement in 1981, NTT developed a new system for purchasing equipment and supplies. This system classifies equipment into three tracks, according to the level of technological sophistication and the extent of additional development needed:

- **Track I:** Procurement of products available in the marketplace. NTT is to place an announcement, examine the qualification of applicants, and make selections on a competitive bidding basis. These are products such as terminal equipment and office supplies.
- **Track II:** Procurement of public telecommunications equipment that is available in the marketplace and that can be placed in service as is or with modifications. NTT is to place announcements, solicit proposals, and examine and select equipment that is best suited for its needs. Examples of these products include cable connectors and online computers.
- **Track III:** First-time procurement of public telecommunications equipment that is unavailable in

the marketplace and must be newly developed for or with NTT. NTT publicly solicits proposals and selects development/production partner(s) from among the applicants, with final purchases made from the selected supplier(s) that produce the most promising equipment. Past developments include switching equipment, carrier transmission equipment, and radio equipment. ☐

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Although this system was implemented to liberalize NTT's traditional procurement policies, it has not significantly opened NTT's markets to US firms. To date, US firms have sold mainly Track I equipment.

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☐ the long-standing close ties between NTT and its family firms during joint product development still remain an impenetrable barrier to all but a few US firms with special technical capabilities to enter the Track III process. ☐

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As a result, NTT procurement has been a generally closed process to all but selected firms. ☐ in advanced electronics, where extensive NTT R&D is involved, the corporation still prefers to deal with major Japanese firms having long-established track records and close ties with NTT research and management personnel. According to Embassy reporting, more than 90 percent of purchases stem from privately negotiated contracts rather than from open bids. NTT sources report that the Engineering Bureau and the Procurement and Supply Bureaus work with family firms to supply NTT's procurement needs and generally exclude domestic and foreign firms that have not participated in the product development process. ☐

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Restraining Foreign Access. Despite the US-Japanese agreement on NTT procurement and the GATT Code on Government Procurement—both of which became effective in January 1981—NTT's imports of telecommunications and other electronics equipment are small (see inset). Although NTT accounts for only a third of the \$4 billion Japanese telecommunications market, it is able to influence all purchases by regulating equipment requirements and design standards. NTT does not provide basic compatibility information to nonfamily firms (foreign or domestic) even though that information is required to build equipment to NTT design specifications. NTT will tell

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prospective suppliers whether or not their products meet NTT specifications but may decline to provide some or all of the specifications—effectively blocking nonfamily firms out of the Japanese market. The recent flurry of NTT purchases notwithstanding, US companies' share of NTT purchases is only about 1 percent. Moreover, many of the recent purchases represent one-time acquisitions. []

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We believe that NTT will continue to make some moves to improve foreign access. According to the Japanese press, President Shinto has attempted to strengthen the role of the Procurement and Supply Bureau—usually less pro-Japanese than the Engineering Bureau—in initiating procurement proposals. In the wake of a recent purge, he installed supporters in key positions in the Procurement Bureau and has placed engineers with overseas experience in important posts in the Engineering Bureau. In addition, since the US-Japanese bilateral agreement, NTT has published some product specifications previously unavailable publicly, published its new procurement rules, and, in some instances, extended the time period for bidding. []

Nevertheless, we doubt that NTT procurement from foreign firms will grow rapidly, particularly from those firms that do not have technical capabilities superior to Japanese firms. Despite Shinto's new policies, NTT engineering personnel will only reluctantly back away from key supplier companies. Those firms, in turn, will push NTT and Tokyo to maintain a cautious approach in changing procurement patterns. NTT officials have repeatedly complained []

[] for example, that foreign companies have been slow to adapt to Japanese technical and commercial requirements and that they have rarely been cost-competitive with Japanese firms. Moreover, [] several important products with lengthy service life—such as digital switching equipment—are already under joint development with Japanese companies, making appreciable foreign purchases unlikely. []

Enhancing Exports. NTT has not only protected the Japanese market but is playing an increasingly important role in facilitating Japanese exports of telecommunications and electronics equipment. Japanese telecommunications exports grew from only about 12 percent of sales in the early 1970s to more than 20 percent in 1982 (figure 6). The Japanese are now a major competitor in markets outside the United States and Western Europe—having built systems in Argentina, Taiwan, Brazil, and Australia. []

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Because of NTT's financial and technical support to Japanese equipment manufacturers, products that emerge from the NTT R&D process can be exported by participating companies at extremely competitive prices. Participating firms often do not pay royalties on products that emerge from the NTT R&D if the products are exported. NTT supplier companies are also permitted to offer manufacturing know-how to third countries for royalties both as a means of earning revenues and as a lever for gaining contracts. []

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[] NTT assists firms exporting telecommunications equipment to LDCs. Since the early 1960s, NTT has provided broad telecommunications assistance to LDCs by establishing training centers, holding forums, and sending engineers to provide technical guidance. With LDCs increasingly introducing large-scale, advanced telecommunications systems, these consulting services are helping Japanese companies to win contracts. According to Japanese press reports, NTT personnel are influencing LDC purchases by matching and combining Japanese equipment with specific country

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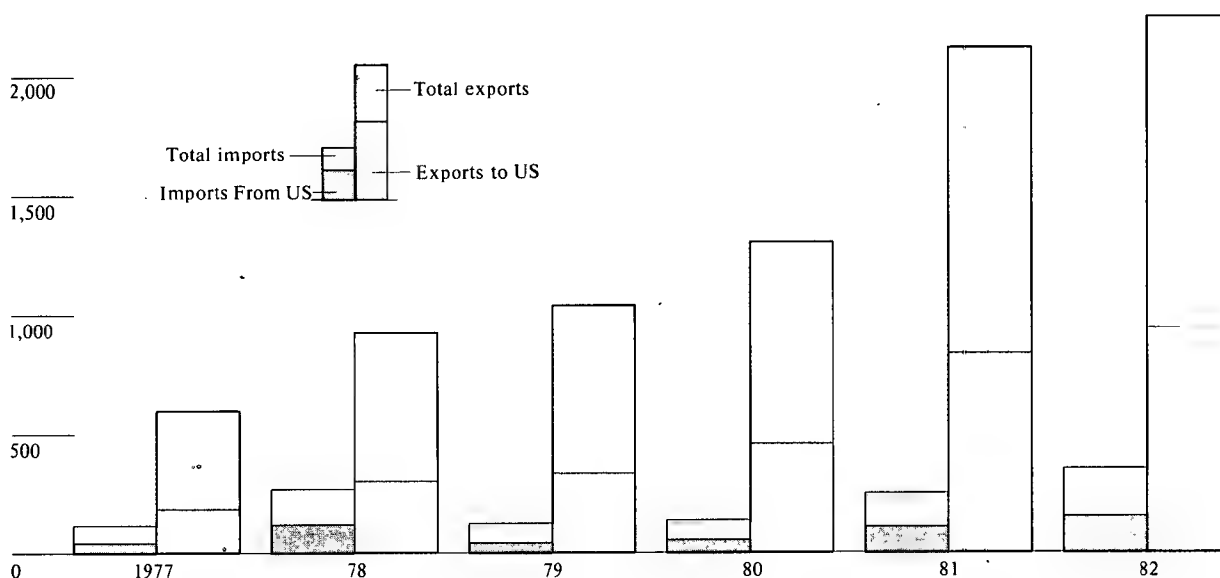
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Figure 6
Japan: Telecommunications Equipment Trade

Million US \$

2,500



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needs. [] NTT provides guidance on export pricing to Japanese firms. []

The Relationship With MITI

NTT and the Ministry of Industry and International Trade (MITI) maintain an important but uneasy association in promoting Japanese R&D in advanced electronics. The Japanese Government has been unsuccessful in forging a clear division of responsibility and authority between NTT and MITI. While NTT has control of the telecommunications network, MITI is responsible for fostering the growth and development of the computer and information-processing industries. As the distinction between computers and telecommunications blurs, these institutional arrangements are increasingly the source of conflict and duplication of effort. []

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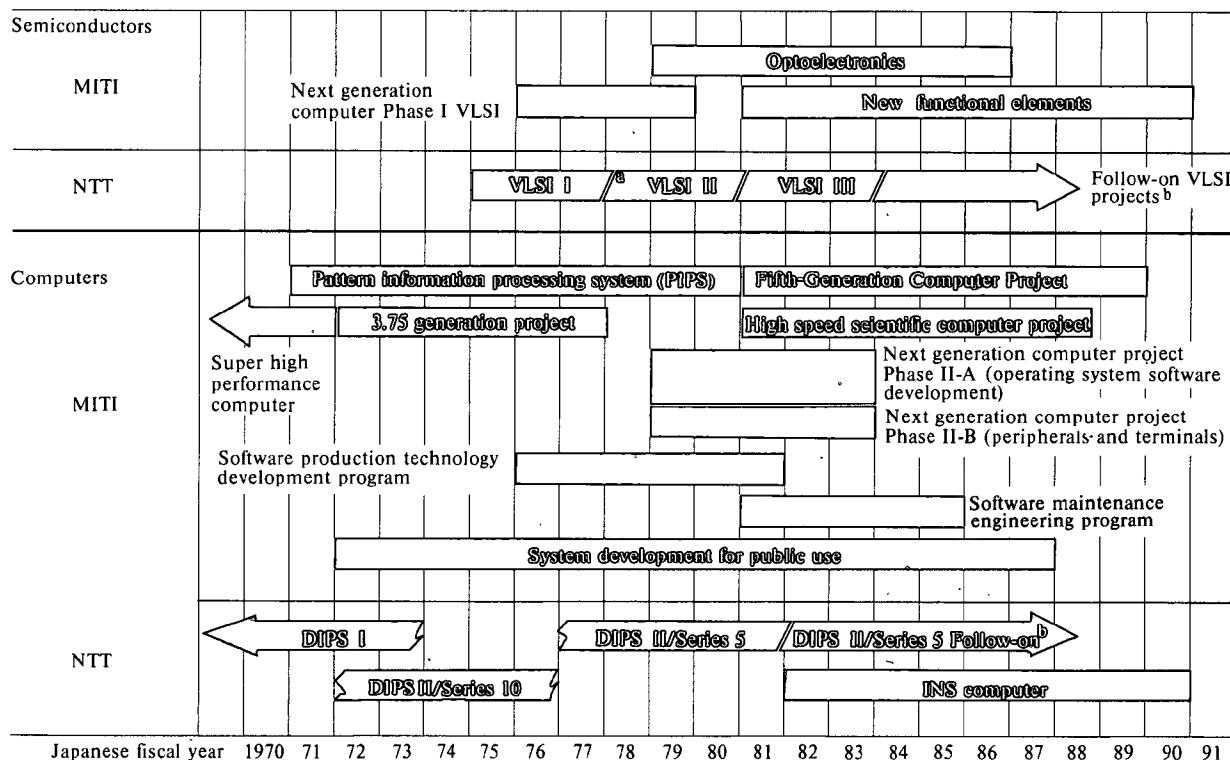
The two bureaucracies have attempted to increase their cooperation, however, as R&D in advanced electronics has grown more costly and complex and MITI faces reductions in its budget. The trend probably has been reinforced since 1981 by the presence of President Shinto, who spent his private industry career with companies strongly tied to MITI. Notable examples of cooperation include (figure 7):

- Coordination of VLSI development. NTT and MITI launched separate programs in the mid-1970s but later agreed to exchange information. According to press reports, MITI focused more effort on logic components while NTT focused more effort on memory and telecommunications-related technologies.

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Figure 7
NTT- MITI: Major Programs



^a Precise cutoff dates for various NTT programs are not known.

Key: MITI=Ministry of International Trade and Industry

NTT =Nippon Telegraph and Telephone

VLSI=Very-Large-Scale Integration

DIPS=Den Den Koshu Information Processing System

INS =Information Network System

^b Estimated follow-on project; precise details and level of commitment not known.

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- Joint NTT-MITI funding of the CAPTAINS program—an information network connecting telephone and television systems.
- NTT performed much of the fiber optics and cable R&D for MITI's development of optical instrumentation and control technology for manufacturing, according to press reports.
- NTT participation in MITI's Fifth-Generation Computer Project is focused primarily on telecommunications-related applications at its Mushashino and Yokosuka laboratories.

Despite increased signs of R&D coordination, NTT and MITI still operate at arm's length. Both agencies, for example, have developed different constituencies among Japanese firms, with NTT's supplier family reported by the Japanese press as generally being much more close-knit. NTT reportedly has been

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highly protective of the R&D information developed in cooperation with its suppliers. Its four laboratories are widely known for their tight secrecy, which has hindered cooperation with MITI's Electrotechnical Laboratory (ETL). ☐

three-year-long VLSI R&D projects with NTT family firms (table 2). These projects covered R&D in devices (such as the 64K and 256K RAMs), as well as the materials (such as high-purity silicon) and production equipment (such as electron-beam and X-ray exposure systems). The participants in the first two projects (VLSI I, 1975 to 1977, and VLSI II, 1978 to 1980) were NEC, Fujitsu, and Hitachi. Toshiba has been admitted recently (October 1982) to VLSI III, which began in 1981. ☐

Many times, however, Japanese electronics firms are able to take advantage of parallel NTT and MITI programs for product development. For example, MITI's Fifth-Generation Computer Project and NTT's INS Computer Project are both designed to produce computers with artificial intelligence. Except for Mitsubishi, the major computer manufacturers benefit from both MITI and NTT funding. Although the value of NTT support is hard to quantify, we believe that NTT involvement has been more important commercially to the firms than the more basic research sponsored by MITI. ☐

☐ industry favors NTT over MITI because it:

- Does not force sharing of information among firms and thus allows each firm to develop its own unique commercial product.
- Provides not only financial and technical support but also a market for products produced by the firms.
- Has strong technical R&D capabilities. ☐

NTT's work in VLSI I, which included the development of the 64K RAM, has contributed to Japanese commercial success in this market. The technology and experience gained from the R&D cooperation with and early sales to NTT have advanced participating firms' technological and manufacturing capabilities to compete with US industry. For example, Japanese firms dominated the early 64K RAM market—achieving a 70-percent world market share in late 1981—and still account for well over 60 percent of the market. ☐

In the second VLSI project, NTT and three family firms developed a 256K RAM. ☐ press reports have stated that NTT transferred important circuit and manufacturing technology on the 256K RAM chip to Fujitsu, Hitachi, and NEC. NTT's transfer of 256K technology began at least as early as 1980—as confirmed by NTT's coauthorship of technical papers on the device with Hitachi. Although we do not know the extent of this transfer, a 1982 paper coauthored by NTT and Hitachi researchers indicates that NTT played a key role in solving one of the more difficult problems associated with the 256K DRAM—soft errors caused by alpha particle radiation. Also, according to the trade press, NTT is continuing to provide design and manufacturing assistance from its laboratories at no cost to the firms. ☐

Impact on Competitiveness of Japanese Firms

NTT's R&D and procurement policies have strengthened the international competitiveness of Japan's semiconductor, computer, and telecommunications industries. We believe that NTT's relationship with its key supplier companies—NEC, Fujitsu, Hitachi, and Oki—has speeded these firms' commercial production of a number of products and facilitated their moves into international markets. Moreover, ☐ Oki would have gone out of business without the technical and financial help of NTT. ☐

Semiconductors⁵

NTT has been a leading force in advancing Japanese semiconductor technology. NTT's major contributions have been through its sponsorship of a series of

We believe the firms' competitiveness has been bolstered by early sales to NTT. The three corporate members of VLSI II began supplying 256K RAMs to NTT in early 1983. NTT's purchases gave the firms valuable experience in producing a complex device

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requiring highly sophisticated fabrication technologies. The 256K RAM is expected to be a bigger seller than the 64K RAM. []

The current VLSI III program could solidify Japan's leadership in the integrated circuit (IC) memory market. The goals include the development of a 1-megabit RAM and computer-aided design (CAD) systems necessary to design increasingly complex ICs. Without NTT's support, we believe the Japanese companies would have a tougher time commercializing the chip for the market. []

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In addition to pursuing state-of-the-art device technology, NTT has been instrumental in advancing the support technologies needed by Japanese firms to produce VLSI devices. NTT has conducted R&D on microfabrication equipment and materials and is now developing CAD systems required for the production of advanced ICs. NTT assisted in the development of two significant support technologies that will be important for the production and testing of the next generation semiconductor devices:

- **Electron Beam Exposure System:** NTT and Hitachi developed an electron beam exposure system that can either generate masks required to fabricate the fine patterns on ICs or write those patterns directly on the silicon substrate. This system is the basis for Hitachi's HL-600, which is currently being marketed.
- **100 Megahertz (MHz) Tester:** NTT has been instrumental in advancing VLSI integrated circuit testing technology in Japan and jointly developed the world's first 100 MHz tester with Takeda Riken. [] NTT provided the R&D services at no cost and shared its previously acquired tester technology with the firm. []

Computers ⁶

NTT computer development programs continue to make significant contributions to the commercial development of computers. NTT has been developing

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standardized, online data communications and processing systems known as the Den Den Kosha Information Processing System (DIPS). The DIPS programs ensure the availability of hardware and software support needed for NTT's data processing services. []

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The DIPS programs have had more impact on overall Japanese commercial computer development than on NTT's development of data communications network. NTT has funded the development of nine DIPS models by Japan's three leading mainframe manufacturers—Fujitsu, Hitachi, and NEC. Although the DIPS computers have not been sold on the open market, technologies developed in these machines have been incorporated in the firms' commercial product lines:

- A comparison of operating characteristics shows that the Fujitsu M-380 and the NEC NEAC-3200/70 are basically identical ⁷ to the DIPS-11/45 and DIPS-11/10 computers, respectively.

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- [] the recently introduced NEC ACOS-750 and Hitachi M-24OH computers are commercial counterparts to the NTT DIPS-11/25 and DIPS-11/15, respectively. []

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NTT's R&D support sharply reduced the level of internal R&D needed by Japanese manufacturers. Overall funding for the DIPS programs has amounted to nearly \$600 million during the 1970s. Although this funding does not seem to be large when compared with the annual R&D budgets of IBM (\$3 billion) or AT&T (\$1.8 billion), we estimate that it represents almost 20 percent of all Japanese computer R&D during the 1970s. We believe DIPS R&D funding for Japanese FY 1983 is about \$48 million. Research and development for the current generation of DIPS machines (the 11/5 series) started in early 1977; the machines are now being shipped to NTT []

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⁷ In terms of CPU cycle time, cache storage capacity, maximum storage capacity, channel throughput, systems configuration, system power consumption and space requirements. []

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We believe the Japanese manufacturers have been able to use NTT resources to meet both NTT and commercial market requirements. NTT has not forced the development of a single unified family of computers in the DIPS program; each firm has been allowed to adopt a different architectural approach and hardware base for its own machine. However, according to NTT technical publications, the NTT laboratories cooperated with each firm in specifying, designing, and manufacturing each firm's DIPS hardware system. Although the mechanisms and full extent of support provided to the individual manufacturers during early stages of product development are unclear, [] NTT provides space at its Yokosuka laboratory for the firms' computer researchers. The NTT laboratories can also conduct parallel research or branch off into complementary areas; in both cases, they share the results with the firms. []

NTT has also been instrumental in supporting development of commercial peripheral equipment. The DIPS program, for example, has fostered development of mass storage and disk storage devices. In October 1980 NTT announced the development of a large-capacity, high-density disk drive to be used to support data processing on the DIPS computers. []

Japanese press reporting indicates that NTT plans to provide over \$1 billion and technical support for advanced computer development during the 1980s. This exceeds the support that will be provided directly to Japanese computer firms by MITI in its much-publicized Fifth-Generation Computer, supercomputer, and new functional devices R&D during the same period. The goals of the NTT programs are to

develop two series of general purpose computers to be introduced in 1987 and 1990 for use by NTT in its integrated information network system. According to press reports, the later series will incorporate revolutionary changes in computer technology using ultra-high-speed components and a radically new design. []

We believe the new NTT programs will have significant commercial implications for Japan's computer industry. As in past programs, we expect Fujitsu, NEC, and Hitachi to produce their own commercial versions of NTT's planned computer systems. NTT technical plans, in fact, delineate the similarities between new DIPS models and new commercial computers by the manufacturers. []

Telecommunications

By helping to upgrade the technological level of family firms and providing a guaranteed market largely protected from outside competition, NTT has been a vital factor in the development of an internationally competitive telecommunications industry. The opportunity to work closely with NTT for product design and to have access to NTT facilities for field trials and advanced engineering developments has provided invaluable support for family firms. NTT provides technology, systems definition, and operating test opportunities to manufacturers for the development of telecommunications products that will be used in the NTT system (table 3). []

The competitiveness of Japan's optical communications, for example, has been greatly enhanced through NTT actions. Although the basic research for fiber optics was done almost exclusively in the United States and Western Europe, the Japanese have become a world leader in this area. This has resulted, in part, from NTT's provision of technology and systems experience, and its willingness to assume developmental risks. NTT was a major supplier of this technology to Japanese firms in the 1970s through its relationship with Bell Laboratories, through its own internal R&D work, and through work contracted out to industry. NTT was also instrumental in forging a national consensus to try to achieve world leadership in fiber

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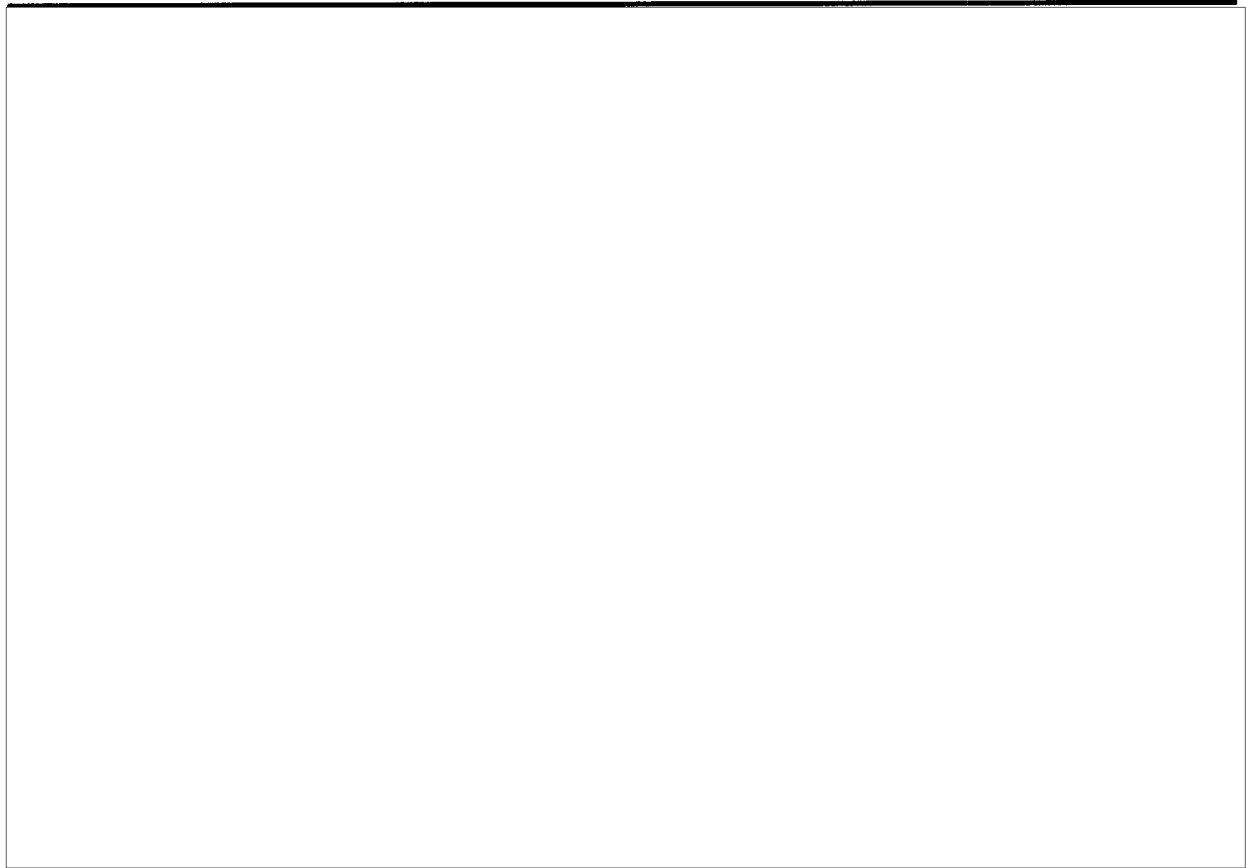
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optics. This consensus led to substantial government funding of fiber optics by MITI and other government agencies and the stimulation of a wide variety of early commercial applications.

NTT continues to direct research on fiber optics, light sources, integrated optics, and new materials for advanced telecommunications systems. The vapor phase axial deposition (VAD) process developed by NTT, for example, may emerge as the world's most efficient process for making the single mode fiber that will be the heart of the next generation of fiber optic systems. A probable motive for pursuing this work was to develop a process that would be an alternative to the modified chemical vapor deposition process developed by US firms. Ultimately, the NTT network may benefit from the development of the VAD process, but the main beneficiaries will be the Japanese companies exporting optical fibers and systems.

When joint R&D with NTT has been unavailable, Japanese telecommunications firms have had considerable problems developing specific products. In telecommunications close relations with an operating company are critical in product design and field testing. For example, because NTT was slow to develop digital switching technology during the 1970s, both NEC and Fujitsu developed local and private branch exchange switches independently to address the burgeoning world market. The resulting switches, however, had multiple design problems. US purchasers of NEC's switches have complained of poor software design, reliability problems, insufficient connecting cable, and the warping of printed circuit boards from excessive heat. The system documentation has also been criticized as having inaccurate and incomplete wiring diagrams.

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NTT's Future Role

There are two forces that will influence the future of NTT and its role in promoting the Japanese electronics industry. One is the planned Information Network System (INS), which is viewed as the infrastructure needed to support the "advanced information society" of the future. This system will require huge investments in future plant and equipment as well as in R&D and would thereby strengthen the Japanese communications industry significantly. The other is the proposed restructuring of NTT, which throws into question its future leadership in guiding technology developments in the electronics industry and in the kinds of services it can provide. []

INS: Leading the Way Into the Next Century

Japanese telecommunications developments through the rest of this century will be guided by the INS. The INS will merge computers and communications equipment and integrate voice, data, video, information processing, and other communications services within a single advanced network. Current NTT plans call for the system to be largely completed by the end of the century at a cost usually estimated at \$100 billion. []

By being one of the first to conduct tests of a fully integrated services digital network, Japan is positioning itself to set international industry standards and to compete in what Western industry analysts agree is one of the largest and fastest growing markets in the world. NTT is building an INS test facility in the Tokyo suburbs; it will be the largest single project ever undertaken by NTT. The facility is intended to provide a proving ground for technology and to gain experience working with digital communications systems. Specific tests of digital switching equipment are already under way, and operations with subscriber connections are scheduled for fall 1984. []

We believe NTT will use the INS to further its control over Japan's telecommunications industry. NTT has publicly argued that the hardware and infrastructure should be in place before opening the telecommunications services market to private-sector competition. [] this will enable NTT and its supplier companies to

develop their own systems software and services and limit foreign entry into their private market. In addition, the program serves as a means to continue supporting the Japanese semiconductor and computer industries. NTT, for example, believes that the telecommunications industry will have requirements for microelectronic devices 100 times faster than those currently used in telephone networks. This leads to requirements for ultra-high-speed computers, which in turn can be used to justify a wide range of R&D on non-silicon-based components. []

INS, if fully implemented, will lead to a tremendous demand for a wide range of telecommunications products; those companies that are able to participate in the R&D and procurement process will benefit greatly. NTT has already selected Japanese firms to develop equipment technologies jointly for the next five to 10 years—virtually locking US firms out of initial INS sales. Since INS will lead to a tremendous demand for a wide range of telecommunications products, the extent to which Japanese firms maintain this hold on the INS program will have a significant impact on Japan's future competitiveness. Nonetheless, US firms' current lead in software technologies needed for communications networks could provide them with some foothold into this market. []

The Moves Toward Breakup

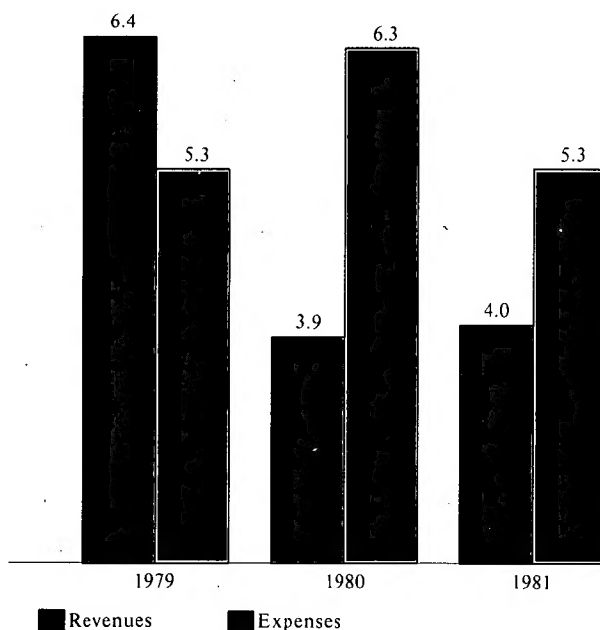
NTT's declining profits have led many Japanese officials to conclude that the corporation must be reorganized and privatized before it becomes a financial drain on the government. The NTT financial base may not support the investment needed for developing the high-level information systems planned for the future. Although NTT currently shows a profit, its annual revenues have been rising at an annual rate of 4 percent and its expenditures at 5 to 6 percent (figure 8). Income is unlikely to grow because the demand for new telephones has peaked, and the market for new services and products is still undeveloped. On the cost side, NTT has large long-term liabilities and associated financing expenses. Continued large investments—which are likely to be made for new information systems—would put additional pressure on profits. Moreover, labor costs represent one-third of total

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Figure 8
NTT: Trends in Growth Rates of
Total Revenues and Expenses

Percent



Source: NTT Annual Report

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costs and reflect the huge bureaucratic nature of the organization. NTT has been slow in reducing excess labor. []

Current government plans seek to reorganize the company in steps, first dividing the company into a special corporation and several regional companies and eventually moving to full private ownership. The special corporation, similar to the Bank of Japan, is envisaged as the central company and would be owned by the government. The regional companies would be either jointly owned by the government and private interests or completely privately owned. Under the currently planned restructuring, data communications and the household equipment divisions will be set up as private companies. []

Proposed changes in the laws and regulations to permit private enterprises to enter many aspects of the telecommunications industry, however, may severely limit the operations of foreign firms in Japan. Although MITI has promoted complete deregulation and the Administrative Reform Committee has recommended a steady transfer of control of telecommunications services to the private sector, the Ministry of Posts and Telecommunications—the government regulator of the industry—is currently pushing a bill that would permit only firms with less than 20-percent foreign equity participation to sell in the Japanese market. If passed, such legislation could severely cripple the operations of many firms, such as multinational banks, airline companies, and credit-card financial firms, already established in Japan and preclude the participation of other potential competitors in this rapidly growing market. []

The restructuring of NTT is highly likely, []

[] but opposing factions have already delayed its implementation and lengthened its planned change into a private company. Originally, the Committee on Administrative Reforms recommended in July 1982 to break the present system into central and regional companies within a five-year period. After considerable debate, a new LDP Reform Draft Bill now recommends that NTT should be first placed under private management (special corporation), and then divided and reorganized within 10 years. Industry analysts believe the Japanese will use this delay to assess the impact of the AT&T divestiture on the US telecommunications industry before major changes are made. At a minimum, however, we expect NTT to be converted into a special corporation. NTT appears to be taking steps in preparation for reform:

- An industrial communications system service division is to be established to offer consulting services to private industry and to design and develop communication systems, such as local area networks and value-added networks, in competition with family firms.

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- A home services division is being set up to unify home service operations, including materials procurement, equipment development, sales, installation, and maintenance.
- Plans to begin independent development and sales of commercial products related to INS have been initiated.
- NTT has begun setting up and/or activating organizations that would control the diffusion of its technologies to private companies. The prime examples are Nippon Denshi Gijutsu, which has been set up to produce prototype components based on NTT technology, and NTEC, which sells NTT technology.
- NTT has begun expanding the number of firms from which it buys products and with which it performs joint R&D. [REDACTED]

The Diet is expected to discuss the reform plan soon and could make a decision as early as spring 1984. [REDACTED]

Reorganization could set in motion changes in NTT's relationships with its suppliers. Competition in areas where NTT has traditionally been a monopoly provider of services will force the company to seek tighter control of costs. This, in turn, will probably force NTT to reduce the subsidy included in its procurement and seek ways to improve the efficiency of its R&D effort. In seeking low cost suppliers, NTT may well be broadening the base of firms with which it does business. Consequently, benefits of association could be shared by a larger number of Japanese firms. Firms with established relationships, on the other hand, could well see their benefits diluted. In addition, because NTT is moving into new business areas, some family firms may come to view NTT more as a competitor than as a partner. On the trade front, we believe reorganization is unlikely to result in a massive opening of the Japanese market to foreign suppliers. Although some loosening is likely, traditional supply patterns will probably rule out complete liberalization. [REDACTED]

Implications for the United States

NTT's involvement in various electronics programs is providing Japanese electronics firms with the production capability and technologies necessary to compete more effectively against US firms. NTT's ability to diffuse know-how and provide a guaranteed market has upgraded Japanese firms' capabilities, making them comparable, and in some instances superior, to US firms. As a result, many US executives believe the US balance of trade in electronics will continue to deteriorate. These effects will intensify not only as NTT continues to provide large government resources for the development of new technologies under the INS program, but also if foreign firms are allowed only limited participation in the communications equipment and services market. Looking further ahead, industry analysts believe the growing competitiveness of Japanese telecommunications equipment, along with continued NTT support of the semiconductor and computer sectors, will have direct effects not only on the electronics industry but on other industries as well. [REDACTED]

Although efforts to liberalize NTT's procurement practices under the US-Japan Bilateral Agreement have resulted in opening up procurement to nonfamily firms, imports of US products will not necessarily increase. We believe that many of the new opportunities are likely to be exploited by nonfamily Japanese firms. As NTT broadens the number of firms participating in its R&D and procurement process, more firms are likely to gain technical capabilities, resulting in increased competition for US firms. Moreover, US firms are likely to find that large investments will be required to compete effectively for NTT business—particularly for participation in joint R&D projects. Nonetheless, a number of US executives believe that they must compete with the Japanese firms in their own market in order to gain an understanding of their competitors and to limit as much as possible any financial and technical strength the Japanese could obtain in an otherwise protected domestic market. [REDACTED]

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Proposed changes in the laws and regulations governing telecommunications services could also limit the operations of existing US firms in Japan and the activities of potential competitors in this market. The current plan advocated by the Ministry of Posts and Telecommunications to maintain government jurisdictional control of the private enhanced services market⁹ and to limit participation in this market to majority-owned Japanese firms (80 percent or more) could enable NTT to continue to maintain its monopoly position. In addition, industrial experts believe that the growth in equipment sales will peak over the next few years as most public telephone and telegraph companies complete the upgrading of their facilities, which in turn will lead to major growth in sales of enhanced services. []

We believe that a restructured NTT will continue to enhance the international competitiveness of Japan's electronics industry. Indeed, industry observers believe NTT will use its \$100 billion, 20-year INS program as a vehicle to continue support of family firms and to minimize electronics imports. Even though procurement is being liberalized, NTT has already selected most of the firms to participate in joint R&D under the INS program; they are all Japanese. Since US firms are not participating in the R&D process, it is unlikely that a significant amount of US equipment will be sold to the INS market. []

We believe NTT's continued technology and market support will contribute to the erosion of US dominance in the world electronics industry. Unlike many US competitors, most of the major Japanese companies are highly integrated and have significant capabilities in all the major components of the information industry. Because of this advantage, the Japanese are well positioned to enhance their market position. As the Japanese capture export markets and make inroads in the US market, there will be significant pressures on individual US companies. To the extent that losses in market share erode the profitability of US manufacturers, their ability to develop new technologies and product lines will suffer. The implications of a reversal in electronics leadership from US producers to highly integrated Japanese firms could

⁹ Private enhanced services include value-added networks and local area networks. []

be far reaching. In particular, the soaring development costs of the latest equipment, such as computer-controlled digital switching systems, are forcing all telecommunications companies to search for foreign business. The world market may not be large enough for all manufacturers, however, and most industry executives believe this will cause the world's communications industry to consolidate. []

NTT will remain an important stimulator of new technological developments, many of which have dual uses in commercial and military applications. The increased technical capability that NTT is developing could frustrate US efforts to control the flow of important military technologies. Specifically, NTT has taken the lead in some research areas of military significance and of interest to the Soviets including:

- Gallium arsenide devices for digital and optoelectronics applications.
- Advanced semiconductor design, manufacturing, and test equipment.
- Computer networks.
- Digital switching.
- Fiber optic communications systems.

As NTT continues to develop these dual-use technologies, we expect the Soviet Union increasingly to target NTT and its suppliers for important military technologies. The Soviets have already attempted the illegal acquisition of advanced technology []

US [] dependency on Japanese suppliers could develop for certain key military components as NTT leads the development of advanced technologies. []

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